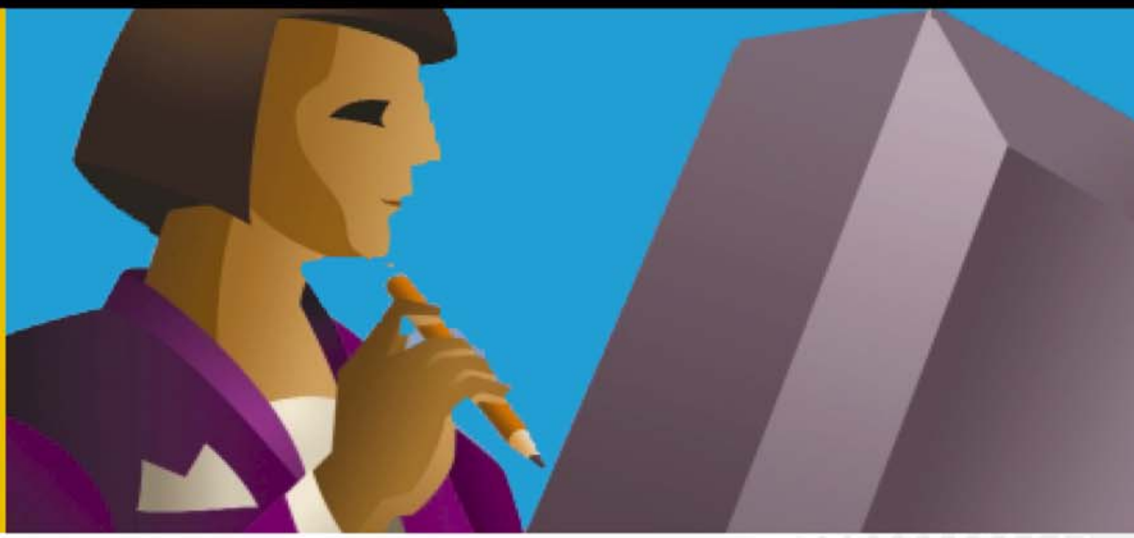
Cisco Systems

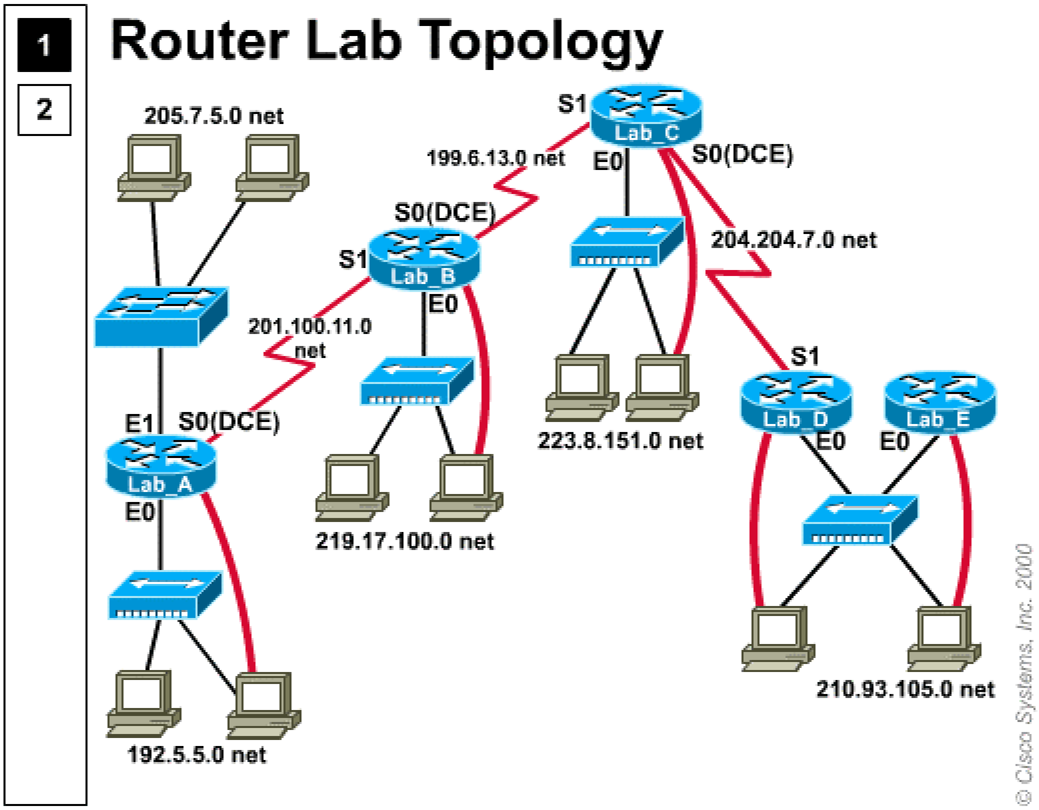
Cisco Networking Academy Program

CCNA 4: WAN Technologies v 2.1.4



Student Lab Manual

Lab 3.3.12.1 WAN commands - overview



Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Password	Vty Password
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 60 min.

Objectives:

- Explore the WAN capabilities of the router
- Use the terminology from the semester 4 online chapters on WANs.
- Experiment with some WAN related IOS commands

Background:

LANs vs. WANs:

This lab is an introduction to Wide Area Networks (WANs) and the part routers play in them. Local Area Networks (LANs) typically consist of a group of computers that are interconnected with hubs or switches using physical cable (twisted pair copper and multimode fiber). WANs are made up of two or more LANs that are geographically separate sites. They typically use services provided by a long distance carrier with transmission over Fiber or Microwave to connect the sites. An organization can own the equipment that interconnects its WAN sites but most often leases WAN links from a service provider.

Routers and WANs:

Although routers can be used to subdivide campus LANs to limit the size of broadcast domains and help maintain security, they are most commonly used to interconnect LANs to make WANs. The router is the interface or gateway from the LAN to the WAN. With most organizations' WANs, each location will have at least one router with an interface or link to one or more other locations in the WAN. This is usually done through a CSU/DSU (Channel Service Unit / Data Service Unit). Even small organizations with a single location today need a router to connect them to the largest WAN in the world, the Internet.

WANs and the OSI Model:

WAN links typically operate at OSI Layer 2 (Data Link) and convert the LAN frame encapsulation such as Ethernet or Token Ring to a wide area Layer 2 frame encapsulation such as HDLC, PPP or Frame Relay. For example, you have two Ethernet LANs interconnected by a WAN link (such as a T1) and a workstation in LAN A needs to connect to a server in LAN B. The workstation sends a packet to the Ethernet interface (for example, E0) of the router in LAN A. That router removes the Ethernet LAN frame header, replaces it with a WAN frame header such as Frame Relay or PPP and sends it out one of its serial interfaces (for example, S0). When the router on LAN B receives the packet on its serial interface, it strips off the WAN frame header and replaces it with the LAN Ethernet frame header. The packet is delivered to the local server on LAN B through the router's Ethernet interface.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have the standard router lab with all 5 routers set up. Before beginning this lab you should read the Networking Academy Second Year Companion Guide, Chapters 8 and 9 on WANs and WAN Design. You should also review Semester 4 On-line chapters

WANs and WAN Design. Work individually or in teams. The following is a list of resources required.

- Standard Cisco 5-router lab setup with hubs and switches
- Workstation connected to the router's console port
- Router Manuals and access to the Cisco web site

Web Site Resources:

- Routing basics
- General information on routers
- 2500 series routers
- 1600 series routers
- Terms and acronyms
- IP routing protocol IOS command summary
- Introduction to WAN technologies

Step 1 - Review router lab WAN physical connections

The standard 5-router lab setup uses WAN serial cables to simulate three wide area network connections between four of the routers (A,B,C and D). These four routers could all belong to corporation XYZ and could be located in different cities across the United States (for example, Lab-A = Anaheim, CA., Lab-B = Boise, ID, Lab-C = Chicago, IL., Lab-D = Dallas, TX.). Routers D and E are attached to a common Ethernet LAN. Normally the cable from the router in each location would connect to a CSU/DSU (Channel Service Unit / Data Service Unit) and then to a WAN link such as a T1 (1.544Mbps) from a service provider. With some routers, the CSU is built-in or can be installed in a modular slot.

One end of each cable is a DB60 (60-pin) connector that attaches to a synchronous serial interface on the router (S0 or S1 in most cases). The other end is a V.35 connector that normally attaches to the CSU/DSU. The CSU/DSU then connects to the digital data line (such as a 56K or T1 link) via a NIU (Network Interface Unit) at the Demarc (demarcation point). This is the separation point between CPE (Customer Premises Equipment) and the WAN link service provider's connection. The standard 5-router lab setup simulates the CSU/DSUs on Point-to-Point WAN links by crossing the connections between the V.35 cables which eliminates the need for the CSU/DSUs.

The Router is typically the DTE (Data-circuit Terminating Equipment) and the CSU/DSU is normally the DCE (Data Communication Equipment). Since there is no CSU/DSU, one of the routers on each simulated WAN link must play the role of the DCE in order to provide the synchronous clocking signal. With the standard lab setup, router Lab-A Serial interface 0 is the DCE and the clock rate is set to 56000 bps on that interface, simulating a 56K digital data circuit. You must attach the DCE (female) cable to this router interface. The DTE (male) serial cable is attached to the Serial 1 interface on the next router Lab-B. No clock is set on the Lab-B S1 interface. Serial interface S0 on router Lab-B then becomes the DCE for the next router.

Step 2 - Identify the router lab WAN connections

Use the standard lab diagram to identify the Wide Area Network (WAN) links. Fill in the table below with WAN information contained in the diagram including the number of the WAN IP network between each pair of routers, the router names that have WANs between them, the interfaces in use on each router and the characteristics of the WAN interface cable.

1. Fill in the following WAN connection table:

WAN IP Network number	Connects FROM Which Router and Interface	DCE or DTE?	Connects TO Which Router and Interface	DCE or DTE?

Step 3 - Diagram the lab WAN connections

Use the standard lab diagram as a starting point and draw the physical and logical WAN topology of the existing lab setup. The main purpose is to identify the routers and Wide Area Network (WAN) links. Identify and label all WAN connections (that is, identify DCE and DTE cables and clock rate, and so on).

2. Diagram the WAN links and their characteristics in the standard lab setup:

Step 4 - Review WAN Connection Options

Refer to the Cisco on-line documentation and the hardware manuals such as the Cisco 2500 Installation and Configuration Guide for the routers you are working with.

3. What are common options or types of Router WAN connections? (Hint: See question 4)

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4. What Router features and/or additional hardware would you need to use ISDN, PPP, Frame-Relay or Dial-up WAN Connections?

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Step 5 - Review WAN encapsulation types

The frame encapsulation used at the Data Link Layer (OSI Layer 2) will vary depending on the WAN technology used between networks connected by routers. The Data Link encapsulation places a header and trailer on the packet. Layer 2 framing on a LAN is different than a WAN and the router must convert between the two.

Check the WAN encapsulation on Lab-A serial interface 0 using the following command:

```
Router# show interface s0
```

5. What is the default WAN encapsulation currently in use on the interface between Routers Lab-A and Lab-B?

____

To see what WAN encapsulation options are available, us the following commands:

Router(config)# interface Serial 0

Router(config-if)#encapsulation ?

6. What are some of the Data Link layer WAN encapsulation types available?

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Step 6 - Using WAN Related Router Commands

The following router show commands can help to explore the WAN capabilities of the router. On a router with standard configurations, try the following show commands from the privileged EXEC mode, note the results, and answer the questions.

7. Show interfaces
What does this command tell you about WAN connections?

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8. Show int s0, show int s1, show int bri0, show int e0, show int e1 etc.
What do these commands tell you about WAN connections?

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9. Show protocols
What does this command tell you about WAN connections?

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10. Show ip route
What does this command tell you about WAN connections?

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11. Show cdp neighbors
What does this command tell you about WAN connections?

Step 7 - Exploring WAN protocol commands

Try some of these additional WAN protocol related commands. Be sure use a space and a ? at the end of the command to see the options available. If the WAN option is not available you will not get an error but no information will be displayed. Write down some of the options that are displayed.

12. Show frame- relay ?

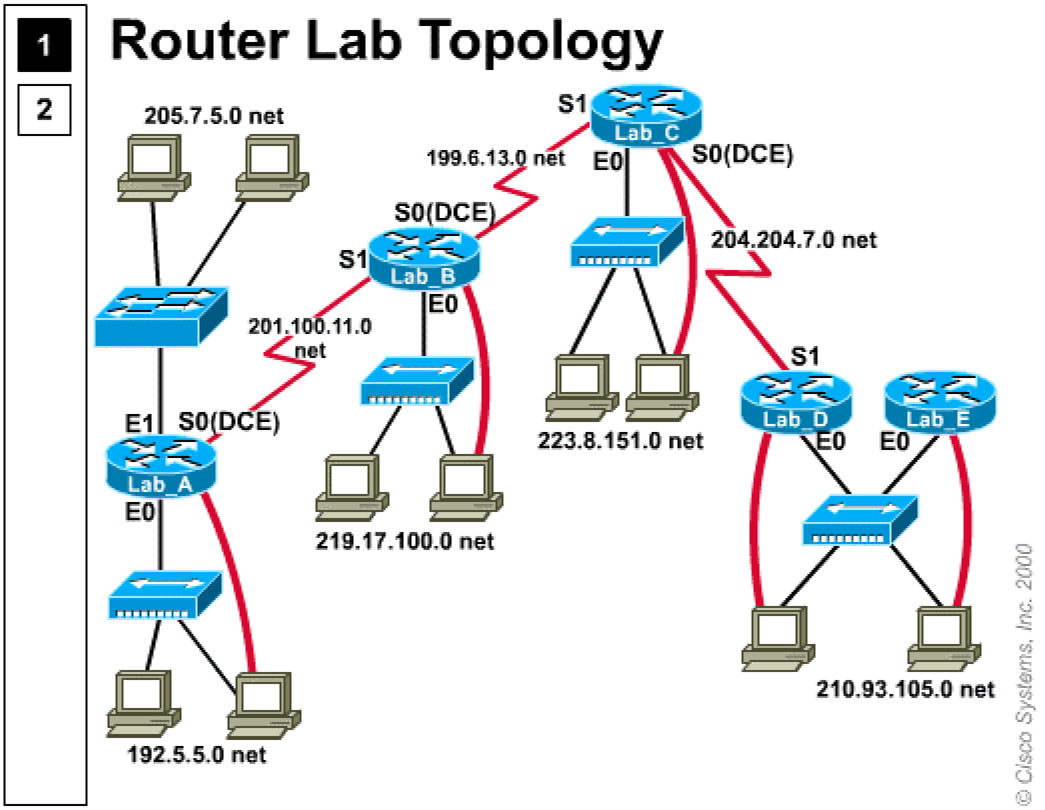
13. Show dialer ?

14. Show ppp ?

15. Show smds ?

16. Show x25 ?

Lab 3.3.12.2 WAN acronyms - overview



Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Pass-word	Vty Pass-word
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 60 min.

Objectives:

- Review some of the more common WAN related acronyms and terminology
- Check your knowledge of WAN acronym definitions

Background:

The computer and networking field uses an incredible number of acronyms and abbreviations, sometimes called TLAs (or Three Letter Acronyms). Many of these are Wide Area Networking (WAN - another TLA) related. It is important when discussing WANs with a coworker or industry representative that you understand the meaning of these acronyms or at least can define the words that make them up. This exercise will highlight some of the more common acronyms and terminology used.

Tools / Preparation:

Before beginning this lab you should read the Networking Academy Second Year Companion Guide, Chapters 8 and 9 on WANs and WAN Design. You should also review Semester 4 On-line chapters on WANs and WAN Design. Compete in teams or work alone. The following is a list of resources:

- Semester 4 Online glossary and the Companion Guide text glossary

Web Site Resources:

- [Terms and acronyms]()
- [Introduction to WAN technologies]()

Step 1 - Define the following WAN acronyms and terms

Try to define as many of these WAN related acronyms as possible as a pre-test and then take this challenge again at the end of the semester to see how many more you know. Give yourself a point for the definition of the acronym and a point for related terms or a more detailed definition.

Acronym	**Definition**	**Related terms / devices / examples or additional explanation**
2B+D		
ATM		
BECN		
BRI		
CHAP		
CIR		
CO		
CPE		
CSU/DSU		
DCE		
DDR		

DEMARC		
DLCI		
DTE		
FECN		
Frame Relay		
IETF		
ISDN		
LAPB		
LAPD		
LCP		
LMI		
MAN		
NCP		
NT1		
NT2		
PAP		
PBX		
PDN		
POP		
PPP		
PRI		
PSTN		
PVC		
RBOC		
SDLC		
SLIP		
SMDS		
SOHO		
SPID		
SS7		
SVC		
T1		
T3		
TA		
TDM		
TE1		
TE2		
X.25		

Lab 4.3.4 PPP configuration - overview

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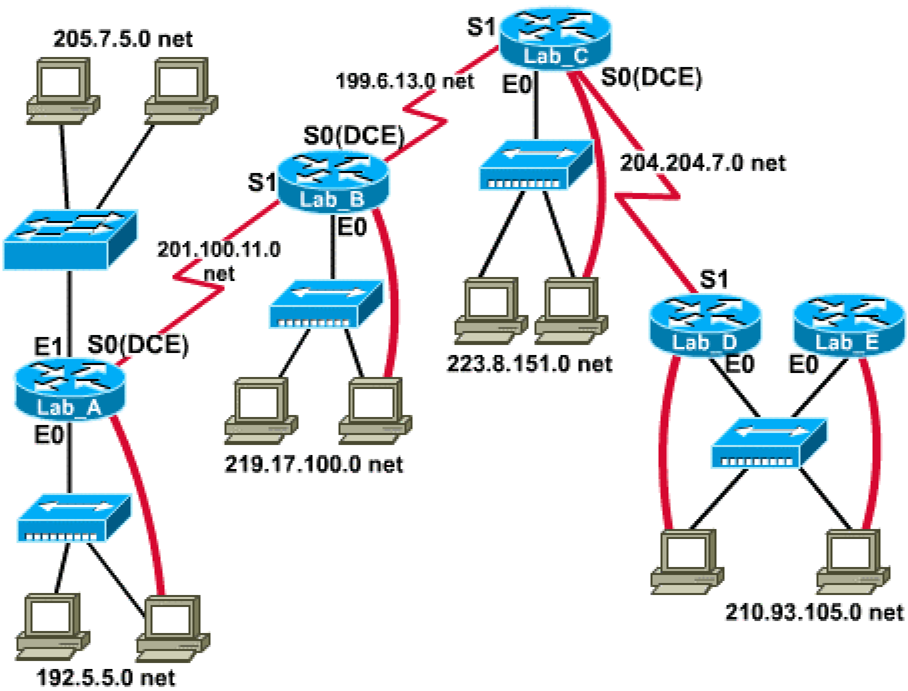
Router Lab Topology



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Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Password	Vty Password
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 60 min.

Objectives:

- Understand how WAN encapsulation types affect synchronous serial connections
- Convert from HDLC to PPP encapsulation on a WAN connection
- Use the terminology of the semester 4 online lesson on WANs.

Background:

This lab focuses on PPP (Point-to-Point Protocol). PPP is a Wide Area Network (WAN) protocol that provides OSI layer 2 (data-link layer) services for router-to-router and host-to-network connections (over synchronous and asynchronous circuits) using a serial interface. It is commonly used by PCs to connect to an Internet Service Provider (ISP) via a dial-up phone line (asynchronous host-to network) or as a WAN encapsulation method between LANs (synchronous router-to-router). PPP is an international, standardized and widely used protocol developed by the Internet Engineering Task Force (IETF). PPP is considered a part of the TCP/IP protocol suite and supports a number of LAN protocols such as IP and IPX and various methods of security authentication such as PAP and CHAP. PPP can be used on various physical media, including twisted pair, fiber or satellite transmission. It uses a variation of High-Speed Data Link Control (HDLC) for packet encapsulation.

Synchronous Serial Ports:
Nearly all Wide Area Network (WAN) links used with Internetwoks are "serial" meaning they transmit bits one after another in a series along a wire or fiber cable. Routers have Synchronous serial ports for WAN connections. They are not the same as the Asynchronous serial connection ports found on PCs and are capable of much higher data rates. Most routers have at least one Synchronous serial port for WAN connection and two Asynchronous serial ports; a Console port for local connection and an AUX port for remote configuration of the router.

The Wide Area Network connections between the routers in the standard Cisco lab setup are synchronous serial links. Speeds for serial digital WAN links can range from a 56Kbps circuit to a T1 (appx. 1.5 Mbps) or a T3 (appx. 45 Mbps). When setting up the serial WAN links for the router lab, the default layer 2 encapsulation is a Cisco proprietary version of High-Level Data Link Control (HDLC) protocol. PPP is more standardized, providing better security and support for dialup connections. With this lab you will convert the WAN links between the lab routers from HDLC to PPP. The PPP encapsulation must be set on both ends of the WAN connection.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have the standard router lab with all 5 routers set up. Before beginning this lab you should read the Networking Academy Second Year Companion Guide, Chapter 10 on PPP. You should also review the Semester 4 On-line chapter on PPP. Work individually or in teams. The following is a list of resources required.

- Standard Cisco 5-router lab setup with hubs and switches
- 2 routers with WAN link between them and HDLC encapsulation (default)
- Workstation connected to the router's console port

- Router Manuals

Web Site Resources:

- Routing basics
- General information on routers
- 2500 series routers
- 1600 series routers
- Terms and acronyms
- IP routing protocol IOS command summary
- Introduction to WAN technologies

Notes:

Select a pair of routers which have a WAN serial link between them such as Lab-A and Lab-B before starting the lab. You could also use Lab-B and Lab-C or Lab-C and Lab-D. Connect your workstation to the console port connection of the first router (Lab-A).

Step 1 - Use the lab diagram and show running-config command to answer the following questions about the Lab-A router:

```
Lab-A# show running-config
```

1. Which Serial interface is used for the WAN link?
2. What is the IP address of this interface?
3. What is the subnet mask of this interface?
4. Is this interface a DCE or DTE connection?
5. How do you know if it is DCE or DTE?
6. What is the clock rate set to for this interface?
7. What is the bandwidth set for this interface (if set)?
8. What would the bandwidth be set to if this were a T1 interface?

Step 2 - Examine the WAN cables attached to Router Lab-A and answer the following questions:

9. Which interface is the cable attached to on Router Lab-A?

10. What type of physical connector connects to the serial port on the router?

11. What type of physical connector is on the other end of the cable?

Step 3 - Use the show interface command and answer the following questions:

`Lab-A# show interface serial 0`

12. What is the status of the interface and the Line protocol?

13. How is the IP address and Subnet mask displayed?

14. What is the Maximum Transmission Unit (MTU)?

15. What is the bandwidth set to?

16. What is the purpose of setting the bandwidth? (Hint: Function of a router)

17. What is the encapsulation currently set to?

Step 4 - Remove the bandwidth setting from Serial S0 with the following series of commands:

```
Lab-A# config t
Lab-A(config)# int s0
Lab-A(config-if)# no bandwidth
```

18. Use the show interface s0 command again. What is default bandwidth set to now?

19. Why do you think this is?

Change the bandwidth back to 56 Kbits with the following series of commands:

```
Lab-A# config t
Lab-A(config)# int s0
Lab-A(config-if)# bandwidth 56
```

Use the `show interface s0` command again to verify that the bandwidth has been changed.

Step 5 - Use the show cdp neighbors command and answer the following questions

`Lab-A# show cdp neighbors`

20. What is the Device ID of the neighboring router?

21. What is the Local Interface that this device was discovered on?

22. What is the capability of the device?

23. What model platform number is it?

24. What is the Port ID for the neighboring router interface?

Step 6 - Check Configuration of the WAN Interface on Router Lab-B

Telnet from Router Lab-A to Router Lab-B and use the lab diagram and the show running-config command to answer the following questions (either telnet to the router name or the IP address of the Serial interface):

`Lab-B# show running-config`

25. Which Serial interface is used for the WAN link?

26. What is the IP address of this interface?

27. What is the subnet mask of this interface?

28. Is this interface a DCE or DTE connection?

29. How do you know if it is DCE or DTE?

30. What is the clock rate set to for his interface?

31. What is the bandwidth set for this interface?

Step 7 - Examine the WAN cables attached to Router Lab-B and answer the following questions:

32. What interface is the cable attached to on Router Lab-B?

33. What type of physical connector is the Serial port on the router?

34. What type of physical connector is on the other end of the cable?

Step 8 - Use the show interface command and answer the following questions:

`Lab-B# show interface serial 1`

35. What is the status of the interface and the Line protocol?

36. How is the IP address and Subnet mask shown?

37. What is the Maximum Transmission Unit (MTU)?

38. What is the bandwidth set to?

39. What is the encapsulation currently set to?

Step 9 - Use the show cdp neighbors command and answer the following questions

Lab-B# show cdp neighbours

40. What is the Device ID of the neighboring router?

41. What is the Local Interface that this device was discovered on?

42. What is the capability of the device?

43. What model platform number is it?

44. What is the Port ID for the neighboring router interface?

Step 10 - Change the WAN Encapsulation on Router Lab-A from HDLC to PPP

Connect your workstation to the console port connection on Router Lab-A and use the following commands to change the WAN encapsulation on Router Lab-A Serial Interface 0 and answer the following questions:

Lab-A(config)# interface serial 0

Lab-A(config-if)# encapsulation ppp

45. Use the show interface s0 command. What is the status of the interface and the Line protocol now?

46. What does this mean?

47. What was the encapsulation previously set to?

48. What is the encapsulation now set to now?

49. Can you Ping or Telnet from router Lab-A to router Lab-B?

50. Why or why not?

Step 11 - Change the WAN Encapsulation on Router Lab-B from HDLC to PPP

Connect your workstation to the console port connection on Router Lab-B (since you can no longer telnet to it) and use the following commands to change the WAN encapsulation to on Router Lab-B Serial Interface 1 and answer the following questions:

```
Lab-B# config t

Lab-B(config)# interface serial 1

Lab-B(config-if)# encapsulation ppp
```

51. Use the show interface s1 command. What is the status of the interface and the Line protocol now?

    ____

52. What is the encapsulation currently set to now?

    ____

53. Can you Ping or Telnet from router Lab-A to router Lab-B?

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54. Why or why not?

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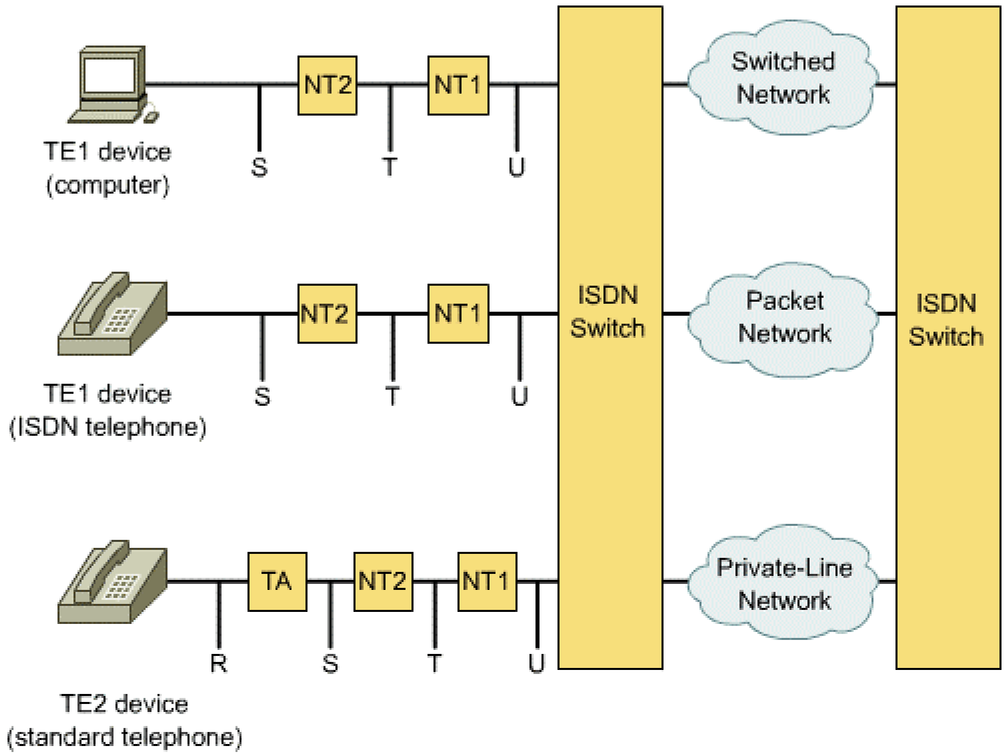
Lab 5.1.3 ISDN terms and devices - overview



Estimated time: 45 min.

Objectives:

- To Review ISDN related acronyms and terminology
- Relate ISDN terms to specific devices

Background:

The Integrated Services Digital Network or **ISDN** was developed to provide digital services over existing telephone wiring. These services can include voice, data and video. ISDN was intended to be the replacement for the standard analog phone system of the PSTN (Public Switched Telephone Network). ISDN standards define the hardware and call setup schemes for end-to-end digital connectivity. It is a dial-up service that is widely used not only in the US but internationally. There are two basic types of ISDN; Basic Rate Interface (BRI) and Primary Rate Interface (PRI). BRI is the slower of the two and is an alternative to dial-up modems. BRI provide 2 x 64Kbps Bearer (B) channels for voice and data and a 16Kbps Delta (D) channel for control and signaling information. This gives a total of 144Kbps for BRI ISDN. PRI typically runs over a T1 physical carrier and provides 23 x 64Kbps B channels and 1 x 64Kbps D channel (for a total of 1.544Mbps). PRI is considered an alternative to dedicated standard leased lines. This exercise will serve as a study guide to help reinforce your understanding of basic ISDN terms and devices to which they relate.

Tools / Preparation:

Before beginning this lab you should read the Networking Academy Second Year Companion Guide, Chapter 11. You should also review the Semester 4 On-line chapters on ISDN. Compete in teams or work alone. The following is a list of resources:

- Semester 4 Online ISDN chapter and glossary
- Second Year Companion Guide, Chapter 11 and glossary

Web Site Resources:

- Terms and acronyms
- Introduction to WAN technologies
- Integrated Services Digital Network (ISDN) Overview and Components

Notes:

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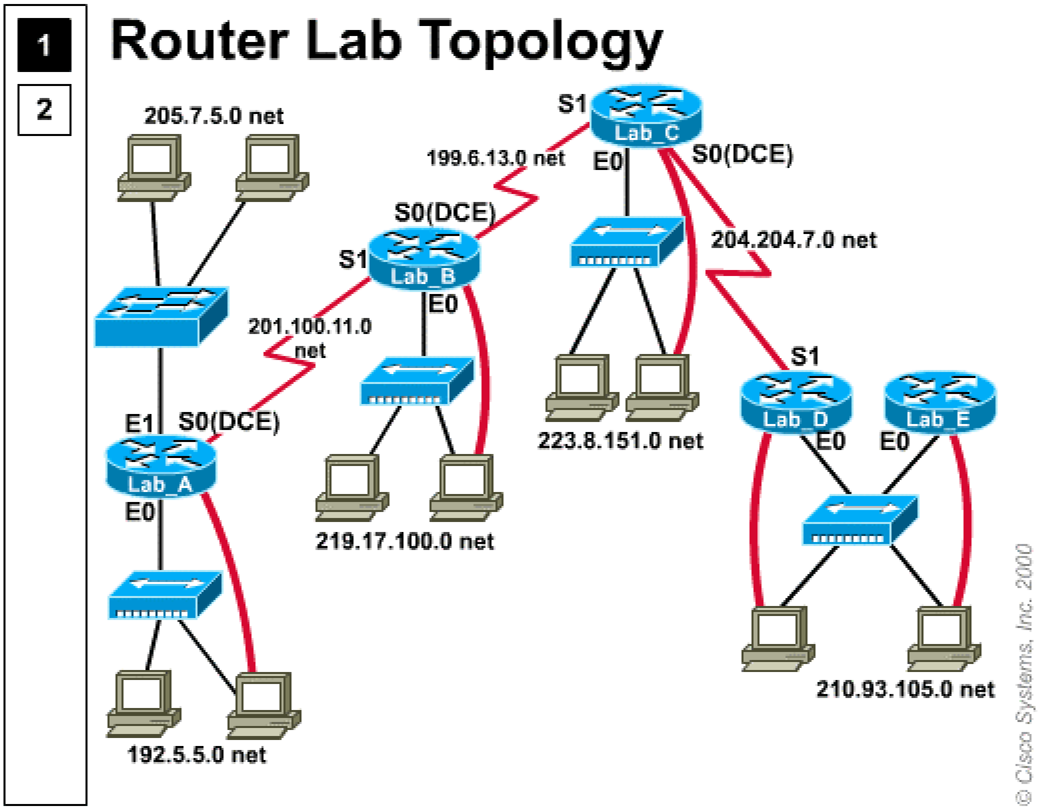
Step 1 - Define the following ISDN terms

The following terms are related to ISDN technology. Define these terms, acronyms and abbreviations using your existing knowledge, the 2nd year companion guide, the online curriculum and the ISDN web site listed. Use the diagram on the first page to relate these terms to devices and connections in the ISDN network.

ISDN Term	Definition and Acronyms	Related Terms/Devices/Examples
2B+D		
BRI		
DCE		
DDR		
DTE		
LAPD		
NT1		
NT2		
PPP		
PRI		
R Reference point		

S Reference point		
T Reference point		
U Reference point		
SPID		
T1		
T3		
TA		
TE1		
TE2		

Lab 6.5.9.1 Frame Relay config - overview



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Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Password	Vty Password
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 60 min.

Objectives:

- To become familiar with Frame Relay related WAN terminology
- To understand the requirements and options for Frame Relay communications
- To simulate the configuration of a Frame Relay switch and links between two routers

Background:

This lab focuses on the Frame Relay Packet Switching Protocol for connecting devices on a Wide Area Network (WAN). Frame Relay is an industry-standard, switched data link layer protocol that handles multiple virtual circuits using HDLC encapsulation between connected devices (routers). Frame Relay is more efficient than X.25, the protocol for which it is generally considered a replacement. Frame Relay is a very widely used and important WAN communication technology. With this lab you will use a router to create a Frame Relay switch (the cloud) and connected two other routers through it to simulate a wide area link between two LANs.

Point-to-Point vs. Frame Relay
Two of the most common types of WAN communication links in use today are 1) Leased Dedicated Point-to-Point permanent circuits and 2) Frame Relay Packet-Switched circuits. The prior labs used PPP (and Cisco HDLC) over a (simulated) leased dedicated point-to-point circuit. This assumes the organization that leased the circuit is paying for the full dedicated bandwidth (such as a T1 at 1.544 Mbps) 24 hours a day, 7 days a week whether they actually use the full bandwidth or not. Packet-switched networks enable end stations to dynamically share the network medium (sometimes referred to as "the cloud") and the available bandwidth and it is possible to only pay for the bandwidth you need. This is referred to as Committed Information Rate (CIR).

Potential Bandwidth Sharing
Frame Relay uses variable-length packets for more efficient and flexible transfers. These packets then are switched between the various network segments (usually phone company Central Offices or COs) until the destination is reached. Statistical multiplexing techniques control network access in a packet-switched network. The advantage of this technique is that it accommodates more flexibility and more efficient use of bandwidth especially between switches within the cloud. Frame Relay is a way of sharing existing T-1 and T-3 lines owned by service providers and potentially getting better use from them. Most telephone companies now provide Frame Relay service for customers who want connections at 56 Kbps to T-1 speeds.

Frame Relay Devices - DTE and DCE
Devices attached to a Frame Relay WAN fall into two general categories: Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE). DTEs are typically located on the premises of and owned by a customer. Examples of DTE devices are terminals, personal computers, routers, and bridges. DCEs are usually carrier-owned (phone company) internetworking devices but can be owned by the customer. The purpose of DCE equipment is to provide clocking and switching services in a network, which are the devices that actually transmit data through the WAN cloud In most cases, these are Frame Relay packet switches themselves. CSU/DSU's are considered DCE.

The connection between a DTE device and a DCE device consists of both a physical-layer component and a Data link-layer component. The physical component defines the mechanical, electrical, functional, and procedural specifications for the connection between the devices. One of the most commonly used physical-layer interface specifications is the Recommended Standard (RS)-232 specification. The link-layer component defines the protocol that establishes the connection between the DTE device, such as a router, and the DCE device, such as a Frame Relay switch (usually at the phone company CO).

Virtual Circuits

Frame Relay provides connection-oriented data link layer communication. This means that a defined communication exists between each pair of devices and that these connections are associated with a connection identifier. This service is implemented by using a Frame Relay virtual circuit, which is a logical connection created between two data terminal equipment (DTE) devices across a Frame Relay packet-switched network (PSN). Virtual circuits provide a bi-directional communications path from one DTE device to another and are identified by a Data-Link Connection Identifier (DLCI).

A number of virtual circuits can be multiplexed into a single physical circuit for transmission across the network. This capability often can reduce the equipment and network complexity required to connect multiple DTE devices. A virtual circuit can pass through any number of intermediate DCE devices (switches) located within the Frame Relay PSN (Packet Switched Network) or cloud. Frame Relay virtual circuits fall into two categories: Switched Virtual Circuits (SVCs) and Permanent Virtual Circuits (PVCs). PVCs are the most common.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have at least 3 of the 5 routers in the standard router lab available. The middle router will act as the Frame Relay Switch and the other routers will connect through it. The middle router must have DCE clock rate and DCE cable ends on both serial ports (S0 and S1). Before beginning this lab you should read the Networking Academy Second Year Companion Guide, Chapter 12 - Frame Relay. You should also review the Semester 4 On-line chapter on Frame Relay.

NOTE:

This is a simulated lab since there will not likely be a real circuit with a Frame Relay cloud available for attachment and testing of the configuration changes made to the routers. The purpose of this lab is to practice the process of configuring the routers to connect to a frame relay WAN link.

The following is a list of resources required.

- 3 Cisco routers with the IOS 11.2 or later
- Middle router serial ports connected to DCE serial cables
- Hubs and/or switch attached to the end routers
- Workstation connected to each router's console port

Web Site Resources:

- Routing basics
- General information on routers
- 2500 series routers
- 1600 series routers
- Terms and acronyms
- IP routing protocol IOS command summary
- Introduction to WAN technologies

Notes:

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Select 3 routers which have WAN serial links between them. The middle router will simulate a Frame Relay switch and the end routers will simulate geographically separate sites connected through the Frame Relay "cloud". This lab worksheet uses routers Lab-A, Lab-B and Lab-C. You will configure the two remote routers (Lab-A and Lab-C) first and then the middle Frame Relay router (Lab B).

Step 1 - Configure the physical 3-router setup

The two cables connected to the middle router (Lab-B) should both be DCE in order to have this router simulate the Frame Relay switch (The DCE cables are labeled on one end). On router Lab-B, connect one of the DCE cables to Serial 0 and the other to Serial 1. The DCE cable from Lab-B serial 1 will connect to a DTE cable going to router Lab-A serial 0 and the Lab-B serial 1 cable will go to the router Lab-C DTE cable on serial 1. Use the tables below for cabling and interfaces.

Router Frame Relay switch	From Serial Intfc # & Type (DCE / DTE)	To Remote Router Name	To Serial Intf # & Type (DCE / DTE)
Lab-B	Serial 0 / DCE	Lab-C	Serial 1 / DTE
Lab-B	Serial 1 / DCE	Lab-A	Serial 0 / DTE

Use the **`show controller`** command to check the DCE/DTE connections.

```
Lab-A#show controller S 0
```

1. What does the **`show controller`** command for S0 indicate?

____

Router	Interface Ethernet 0	Interface Serial 0	Interface Serial 1	Subnet Mask
Lab-A (remote)	192.5.5.1	201.100.11.1	Not used	255.255.255.0
Lab-B (switch)	Not used	DLCI 21	DLCI 20	N/A
Lab-C (remote)	223.8.151.1	Not used	201.100.11.2	255.255.255.0

2. Draw the 3 router set up showing cabling, interfaces, IP addresses and DLCIs.
(Hint: use the table above for the diagram)

Step 2 - Check the WAN Interface on remote router Lab-A

Connect your workstation to the console port connection on Router Lab-A and use **`show interface`** command to answer the following questions:

`Lab-A# show interface serial 0`

3. What is the IP address and number of subnet bits for this interface?

____

4. What is the status of the interface and the Line protocol?

____

5. What is the encapsulation currently set to?

____

Step 3 - Configure the Serial Interface on Lab-A for a Frame Relay Connection

Connect your workstation to the console port connection on Router Lab-A and use the following commands to set up Frame Relay on interface Serial 0. Note that if your are using Cisco IOS version 11.2 or newer the Frame Relay DLCI and LMI type can be detected automatically and will not need to be configured manually.

Lab-A - Remote Router Frame Relay Configuration

Prompt and Command	Purpose
***** Configure Interface S0 *****	
`Lab-A#config t`	Configure from terminal
`Lab-A(config)# interface Serial0`	Select interface S0 to configure
`Lab-A(config-if)# ip address 201.100.11.1 255.255.255.0`	Set the IP address and subnet mask for S0 (use the standard router lab IP)
`Lab-A(config-if)# encapsulation frame-relay`	Change the data link encapsulation from HDLC to Frame Relay. Use IETF if connecting to non-Cisco router. Default is Cisco encapsulation.
`Lab-A(config-if)# no shutdown`	Bring up interface S0
`exit`	
***** Configure Interface E0 *****	
`Lab-A(config)# interface Ethernet0`	Select interface E0
`Lab-A(config-if)# ip address 192.5.5.1 255.255.255.0`	Set the IP address and subnet mask for E0 (use the standard router lab IP)
`Lab-A(config-if)# no shutdown`	Bring up interface E0
`exit`	
***** Configure IGRP Routing Protocol *****	
`Lab-A(config)# router igrp 100`	Enables IGRP routing protocol process
`Lab-A(config-router)# network 201.100.11.0`	Selects network 210.100.11.0 to broadcast and receive IGRP updates
`Lab-A(config-router)# network 192.5.5.0`	Selects network 192.5.5.0 to broadcast and receive IGRP updates
`Control Z and Copy run start`	

Step 4 - Use the show running-config interface command to verify the configuration of S0

`Lab-A#sh run`

6. What information was displayed about Lab-A interface S0?

____

Step 5 - Check the WAN Interface on remote router Lab-C

Connect your workstation to the console port connection on Router Lab-C and use **`show interface`** command to answer the following questions:

`Lab-C# show interface serial 1`

7. What is the IP address and number of subnet bits for this interface?

____

8. What is the status of the interface and the Line protocol?

____

9. What is the encapsulation currently set to?

____

Step 6 - Configure the Serial Interface on Lab-C for a Frame Relay Connection

Connect your workstation to the console port connection on Router Lab-C and use the following commands to set up Frame Relay on interface Serial 1. Note that if you are using Cisco IOS version 11.2 or newer the Frame Relay DLCI and LMI type can be detected automatically.

Lab-C - Remote Router Frame Relay Configuration

Prompt and Command	**Purpose**
***** Configure Interface S1 *****	
`Lab-C#config t`	Configure from terminal
`Lab-C(config)# interface Serial1`	Select interface S1 to configure
`Lab-C(config-if)# ip address 201.100.11.2 255.255.255.0`	Set the IP address and subnet mask for S1 (use the standard router lab IP)
`Lab-C(config-if)# encapsulation frame-relay`	Change the data link encapsulation from HDLC to Frame Relay. Use IETF if connecting to non-Cisco router. Default is Cisco encapsulation.
`Lab-C(config-if)# no shutdown`	Bring up interface S1
`exit`	
***** Configure Interface E0 *****	
`Lab-C(config)# interface Ethernet0`	Select interface E0
`Lab-C(config-if)# ip address 223.8.151.1 255.255.255.0`	Set the IP address and subnet mask for E0 (use the standard router lab IP)
`Lab-C(config-if)# no shutdown`	Bring up interface E0
`exit`	
***** Configure IGRP Routing Protocol *****	
`Lab-C(config)# router igrp 100`	Enables IGRP routing protocol process

`Lab-C(config-router)# network 201.100.11.0`	Selects network 201.100.11.0 to broadcast and receive IGRP updates
`Lab-C(config-router)# network 223.8.151.0`	Selects network 223.8.151.0 to broadcast and receive IGRP updates
`Control Z and Copy run start`	

Step 7 - Use the show running-config interface command to verify the configuration of S1

`Lab-C#sh run`

10. What information was displayed about Lab-C interface S1?

____

Step 8 - Configure Lab-B as a Frame Relay Switch

Connect your workstation to the console port on Router Lab-B and use the following commands to enable Frame Relay switching and define interfaces Serial 0 and Serial 1 as DCE.

Lab-B - Frame Relay Switch configuration

Prompt and Command	Purpose
***** Enable Frame Relay Switching *****	
`Lab-B#config t`	Configure from terminal
`Lab-B(config)# frame-relay switching`	Starts the frame relay switching process
***** Configure Interface S0 *****	
`Lab-B(config)# interface Serial0`	Select interface E0
`Lab-B(config-if)# no ip address`	Specify no IP address for S0
`Lab-B(config-if)# encapsulation frame-relay`	Change the Layer 2 data link encapsulation from HDLC to Frame Relay.
`Lab-B(config-if)# clock rate 56000`	Specify the synchronous clock rate for the DCE side of the interface
`Lab-B(config-if)# frame-relay intf-type dce`	Specify the interface as a DCE device
`Lab-B(config-if)# frame-relay route 21 interface serial 1 20`	Define frame route so packets coming in on S0 DLCI 21 should go to S1 DLCI 20
`Lab-B(config-if)# no shutdown`	Bring up interface S0
***** Configure Interface S1 *****	
`Lab-B(config)# interface Serial1`	Select interface S1
`Lab-B(config-if)# no ip address`	Specify no IP address for S1
`Lab-B(config-if)# encapsulation frame-relay`	Change the Layer 2 data link encapsulation from HDLC to Frame Relay.
`Lab-B(config-if)# clock rate 56000`	Specify the synchronous clock rate for the DCE side of the interface
`Lab-B(config-if)# frame-relay intf-type dce`	Specify the interface as a DCE device
`Lab-B(config-if)# frame-relay route 20 interface serial 0 21`	Define frame route so packets coming in on S1 DLCI 20 should go to S0 DLCI 21
`Lab-B(config-if)# no shutdown`	Bring up interface S0

`Control Z and Copy run start`	

Step 9 - Use the show running-config interface command to verify the configuration of S0 and S1.

Note that there are several commands added by the router.

`Lab-B#sh run`

11. What information was displayed about Lab-B interface S0?

____

12. What information was displayed about Lab-B interface S1?

____

Step 10 - Confirm that the Line Is Up by entering the show interface serial 0 command:

`Lab-A# show interface serial 0`

13. What is the status of the Serial frame link?

____

14. How many LMI messages were sent and received?

____

15. What does this mean?

____

16. What is the LMI type?

____

Step 11 - Verify the Frame Relay PVC status for router Lab-A (remote router)

`Lab-A# show frame pvc`

17. What is the DLCI number of the connection? (DLCI=)

____

18. What is the status of the PVC? (PVC Status =)

____

Step 12 - Check the Frame Relay map for router Lab-A (remote router)

`Lab-A# show frame map`

19. What is local interface number, IP address of the switch interface and the DLCI of the connection?

____

20. What is the status of the PVC?

Step 13 - Check the LMI status for router Lab-A (remote router)

`Lab-A# show frame lmi`

21. What is local interface number and is it DCE or DTE?

Step 14 - Verify the Frame Relay PVC status for router Lab-B (the switch)

`Lab-B# show frame pvc`

22. What are the DLCI numbers of the connections?

---

23. What is the status of the PVCs?

Step 15 - Verify the Frame Relay routing table for router Lab-B (the switch)

`Lab-B# show frame route`

24. What information is shown? Input intf, Input DLCI, Output Intf, Output DLCI, Status

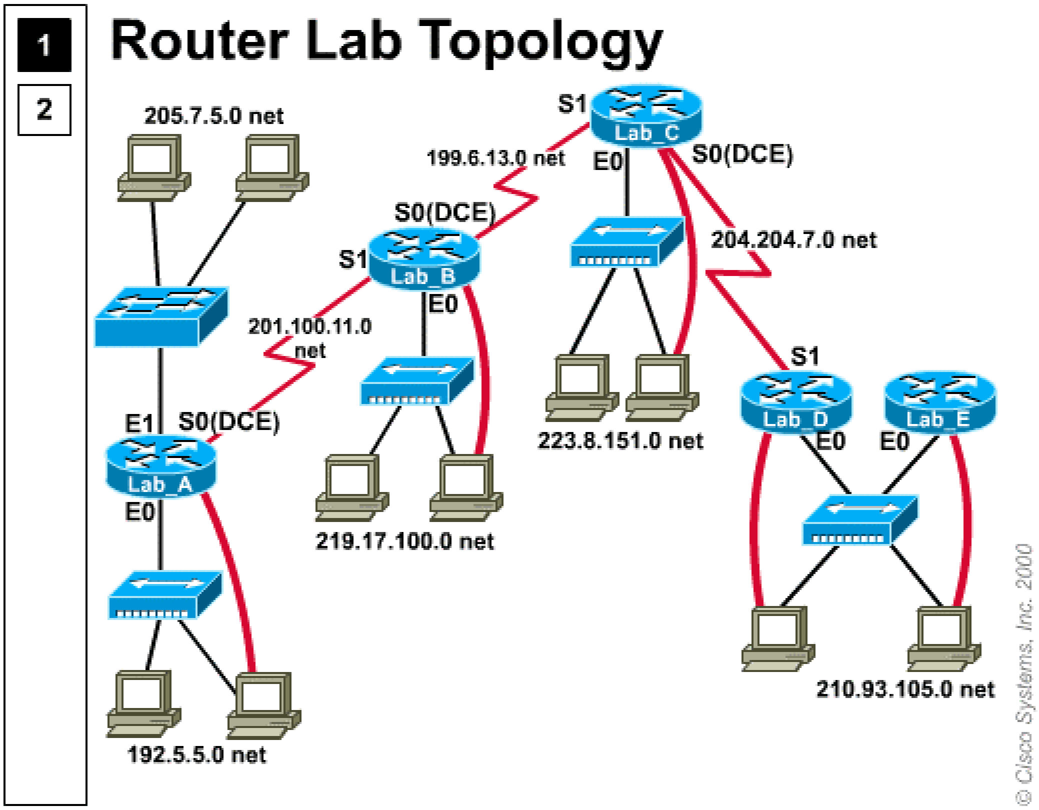
---

Step 16 - Verify the Frame Relay PVC status for router Lab-B (the switch)

`Lab-A# ping 201.100.11.2`

25. What was the result?

Lab 6.5.9.2 WAN web research - overview



1

2

Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Pass-word	Vty Pass-word
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 60 min.

Objectives:

- Explore semester 4 WAN technologies further
- Investigate other WAN and networking technologies
- Use the World Wide Web as a research tool
- Put together a brief presentation for the class on a WAN related topic

Background:

There is a tremendous amount of information available on the web related to networking in general and Wide Area Networking in particular. The purpose of this lab is to begin to use the web as a research tool to expand your knowledge of the basic WAN technologies covered in semester 4. There are also a number of other WAN technologies in use that you can investigate. When you become aware of a new WAN technology, term, or acronym during a conversation or in your reading, you can research it with several web-based tools to help increase your understanding of it. You will select one or more topics or terms to research and then document your findings. The goals for this lab are to become more familiar with some of the web-based research tools available and to use the information you have collected to put together a brief presentation for the class on a WAN-related topic of interest to you.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a PC with web access and PowerPoint available. The following is a list of resources required. Use PowerPoint or a similar tool if possible to develop your presentation. The presentation should not be more than 3 to 5 pages long and should not last more than 10 minutes with 5 minutes for questions and answers.

- Workstation with browser (Internet Explorer or Netscape) and PowerPoint software installed

Web Site Resources:

- Terms and acronyms
- Introduction to WAN technologies
- Cisco web site search engine (select tech docs or products)
- Networking terminology definitions and web links
- Networking concepts search engine

Notes:

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Step 1 -

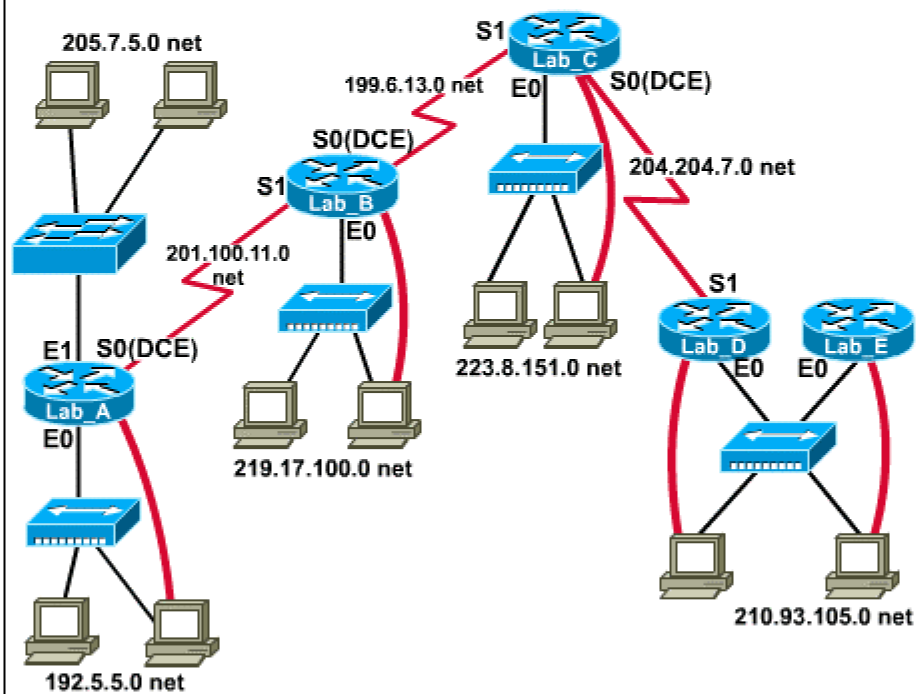
Select your research term or networking concept from the list in Lab 3.3.12.2 WAN Acronyms lab or pick you own. Choose terms and concepts that you are interested in or that you feel are important in this industry. Then use the web-based tools listed in the Web Site Resources section of this lab to find out more information on the topic(s) you have selected.

Term/Concept	Web Site Researched	Findings

Lab 7.3.3 AUX dial-up - Overview

1
2

Router Lab Topology



1
2

Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Password	Vty Password
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Estimated time: 30 min.

Objectives:

- To understand both "in-band" and "out-of-band" router management techniques
- To compare Synchronous serial Interfaces with Asynchronous serial interfaces
- To learn the requirements for using a dial-up link with a modem to configure a router
- To become familiar with the use of the router AUX port for out-of-band management
- Use Config Maker to create a dial-up Asynchronous WAN link

Background:

Wide Area Network Scenario

This lab focuses "out-of-band" router management using the AUX port on the router and a modem. You can configure and monitor routers and other networking equipment using both in-band and out-of-band techniques. For example, let's say Router Lab-A is in Anaheim, CA. and Lab-B is in Boise, ID. They are connected via a wide area link such as T1 Frame Relay, PRI ISDN or Point-to-Point over T1. Regardless of which you use, your WAN link has a the bandwidth or "speed" of a T1 (1.544 Mbps). You are a Network Administrator in Anaheim and wish to make some configuration changes or check the status for the Lab-B router in Boise.

In-Band Network Management

If you are attached to the console of router Lab-A and telnet to Router Lab-B across the wide area link, your connection to router Lab-B is considered in-bandwidth or "in-band" since you are using the same WAN link that the data travels on to manage the Lab-B router. If the WAN link goes down or there is a problem with the configuration of the Lab-B router that contributes to the down WAN link, you cannot get to the Lab-B router to monitor or change its configuration since the WAN link is down. In-band management is very common and is preferred if the WAN link is up.

Out-of Band Network Management

If the Wan link is down you need a "back-door" or an "out-of-band" method to get to the router and check it out to help troubleshoot the problem. This can be provided by redundant Synchronous WAN serial links to other interfaces on the router. They can be the same as the existing high speed WAN link or can be slower such as BRI ISDN or perhaps a synchronous 56kbps digital data circuit. You can also get to the router by use of its Asynchronous serial ports. Most routers have 2 Asynchronous ports in order to manage the router "out-of-band"; the Console port and the AUX or Auxiliary port.

The use of the Asynchronous console port or the AUX port is considered "out-of-band" management.

The Console port vs. The AUX port

The primary method of configuring routers with these labs has been with the console port. With the console port, your workstation is directly attached to the router with a special rollover cable and bypasses any other interfaces on the router. The console port is normally set to run at 9600 bps (8 data bits, no parity and 2 stop bits or 8-N-2) and does not support hardware flow control. The AUX port requires a modem be attached and allows you to dial into the router from home or any other location. The AUX port can run at the same speed as the

fastest modems up to 56kbps and supports hardware flow control. The Console and AUX ports normally use RS-232 serial DB25 connectors (converted to RJ45).

<u>Synchronous vs. Asynchronous Serial Interfaces</u>
Nearly all Wide Area Network (WAN) links used in Internetworking are "serial" meaning they transmit bits one after another in a series down the wire or fiber cable. They are not the same as the Asynchronous serial connection ports found on the back of most PCs and those used with modems. The console connection from a workstation to the console port on the router is an Asynchronous connection which uses start and stop bits to separate the data bits in the stream. The bit rate on the Asynchronous router console port is set to 9600 bits per second (bps). Asynchronous serial connections are commonly used with short distance connections for terminals (to routers and switches) or for dial-in modem connections which are limited to 56kbps (Kilobits per second or 56 thousand bits per second). A modem can be connected to the AUX port on the router to allow you to dial in Asynchronously and diagnose problems. With this lab you will practice setting up a modem with the router and dialing in from another location to configure it remotely. Note that the AUX port can also be used for Dial-on Demand routing in case the main WAN serial link is down.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have a router available and preferably two phone lines into the router that can function with an analog phone connection. (Some phone switches will not work for this lab). If a connection can be made to the phone jack and you have a dial tone then one line will work if the lab can be done from home or another location. This is a hands-on lab and assumes that the phone lines area available for dial in to the router. If phone lines are not available it is still worthwhile to work through the lab and do those portions that are possible. If a phone line is not available it may be possible to simulate this lab with a modem eliminator between the COM port of the PC dialing in and the Router's AUX port.

NOTE:

You can use ConfigMaker to set up a dial in port or an Asynchronous WAN backup port to simulate this lab.

The following is a list of resources required:

- Cisco router with AUX port

NOTE:

>Some routers do not have an AUX port

- Standard Asynchronous analog Modem (USR 56K or similar)
- Rollover cable with DB25 modem connector and RJ45 router connector

- Phone cable from modem to phone jack
- 2 Direct inward dial-up analog phone lines (preferably)
- Router Manuals and modem manuals
- Remote PC with modem to dial in to the router
- Workstation with HyperTerminal and a console connection

Web Site Resources:

- Terms and acronyms
- IP routing protocol IOS command summary
- Introduction to WAN technologies
- Cisco ConfigMaker information and download

Step 1 - Prepare the Router Configuration for AUX Dial-in

A. Verify that you have a router with an AUX port.

Look at the back of the router and check to see that there is an AUX port next to the console port. Some routers such as the 1600 Series do not have an AUX port.

B. Provide password security for dial-in to the AUX port.

1. Connect to the router with a workstation using the console port and HyperTerminal.
2. Set a password for the AUX port as follows:

```
Router# Config t
Router(config)# line aux 0
Router(config-line)# password cisco
Router(config-line)# login
```

C. Discover the modem automatically.

1. The Cisco IOS software contains a database of modem capabilities for most modems. You can configure a router to automatically attempt to discover what kind of modem is connected to the line and then to configure that modem. To automatically discover which of the supported modem strings properly initializes your modem and then initialize the modem, enter:

```
Router(config-line)# modem autoconfigure discovery
Router(config-line)# modem dialin
```

D. Set the router port transmission speed (try not to use the baud command if you do not need to, it can cause problems with the router).

1. Enter the following command to set the speed

```
Router(config-line)# speed 38400
```

2. Enter the following command to hang up the modem automatically

```
Router(config-line)# autohangup
```

E. Verify that Hardware flow control is used with Data Carrier Detect (DCD) and Data Terminal Ready (DTR) operations.

1. Enter the following command set flow control

```
Router(config-line)# flowcontrol hardware
```

F. Configure the line Asynchronous data transmission parameters to 8 data bits, No Parity and 2 Stop bits (8, None and 2 or 8-N-2)
   1. Enter the following command to set the number of data bits to 8

   ```
   Router(config-line)# databits 8
   ```

   2. Enter the following command to set the parity to None

   ```
   Router(config-line)# parity none
   ```

   3. Enter the following command to set the number of data bits to 8

   ```
   Router(config-line)# stopbits 2
   ```

G. Check the configuration of the AUX port with the show running-config command. The output from the command should show the following port characteristics:
   - line aux 0
   - password cisco
   - login
   - autohangup
   - flowcontrol hardware

H. Copy the running configuration to the startup configuration to save the AUX port configuration commands you have entered.

```
Router# copy run start
```

I. Plug the rollover cable RJ45 connector into the AUX port on the back of the router

Step 2 - Prepare the Workstation used for Dial-in

A. Review the workstation's 'HyperTerminal' configuration.
Click on Start, Programs, Accessories, and then HyperTerminal. Right Click on the icon that is defined for AUX access to the Cisco Router and then click Properties. If one does not exist you can create it using the settings shown in the answers to the worksheet. On the Properties screen, click the Phone Number Tab and then click the on the Configure button. Fill in the following table with the information indicated.

B. Configure the workstation modem (internal or external) to match the transmission settings (speed, Data bits, Parity, Stop bits and Flow Control) for the router AUX port. Fill in the following table with the settings and values you used:

Configuration Option	**Current Setting(s)**
COM Port	Modem Driver Name
Bits per second (baud)	34800
Data bits	8
Parity bits	None
Stop bits	2
Flow control	Hardware

Step 3 - Dial-in to the router

Using the phone number of the line to the router or a modem eliminator (null modem) cable connected to the router. You should get a prompt and be able to configure it remotely.

Step 4 - Use ConfigMaker to create a dial-in Asynchronous WAN link

Start ConfigMaker and select a **Cisco 2501 router**. Select a **Dial-in PC with Modem** for dial-in and add an **Async** link between them. Double click on the router to see the configuration generated.

Lab Activity 9.2.1 Creating subnets

The table shows an example, which is covered in this activity.

Host IP Address	Class	Subnet Mask	No. of Subnet Bits	Maximum # of Subnets s = sn - 2	Ordinal Number of this Subnet
138.101.114.250		255.255.255.192			
Subnet Address of This Subnet or Wire		Range of Host Addresses For this subnet		Broadcast Address of This Subnet	

Step 1 - Translate Host IP Address and Subnet Mask into binary notation.

	138.	101.	114.	250
IP Address	10001010	01100101	01110010	11111010
Mask	11111111	11111111	11111111	11000000
	255.	255.	255.	192

Step 2 - Determine the Network (or Subnet) where this Host address lives:

1. Draw a line under the mask
2. Perform a bit-wise AND operation on the IP Address and the Subnet Mask
   Note: 1 AND 1 results in a 1, 0 AND anything results in a 0
3. Express the result in Dotted Decimal Notation
4. The result is the Subnet Address of this Subnet or "Wire" which is 138.101.114.192

	138.	**101.**	**114.**	**250**
IP Address	10001010	01100101	01110010	11111010
Mask	<u>11111111</u>	<u>11111111</u>	<u>11111111</u>	<u>11000000</u>
Network	10001010	01100101	01110010	11000000
	138	**101**	**114**	**192**

Step 3 - Determine which bits in the address contain Network information and which contain Host information:

1. Draw the **"Great Divide" (G.D)** as a wavy line where the 1's in the Default Subnet Mask would end for this class address (if no subnetting occurred). In our example, the IP Address is a Class B address, and so the Default Subnet Mask is 255.255.0.0.
2. Draw the **"Small Divide" (S.D.)** as a straight line where the 1's in the given mask actually end. The network information ends where the 1's in the mask end

3. The result is the **"Number of Subnet Bits"** may be determined by simply counting the number of bits between the G.D. and S.D., which in this case is 10 bits.

Step 4 - Determine bit ranges that are for subnets and for hosts:

1. Label the **"subnet counting range"** between the G.D. and the S.D. (these are the bits that are being incremented to make the subnet numbers or addresses).
2. Label the **"host counting range"** between the S.D. and all of the way to the end on the right (these are the bits that are being incremented to make the host numbers or addresses).

Step 5 - Determine the range of host addresses available on this subnet, and the broadcast address on this subnet:

1. Copy down all of the network/subnet bits of the Network Address (i.e. all bits before the S.D.)
2. In the host portion (to the right of the S.D.) make the host bits all 0's except for the right most bit (or least significant bit), which you make a 1. This gives you the first Host IP Address on this subnet, which is the first part of the **result** for **"Range of Host Addresses for This Subnet,"** or in our example **138.101.114.193.**
3. Now, in the host portion (to the right of the S.D.) make the host bits all 1's except for the right most bit (or least significant bit), which you make a 0. This gives you the last Host IP Address on this subnet, which is the **last part** of the **result** for **"Range of Host Addresses for This Subnet,"** or in our example **138.101.114.254.**
4. In the host portion (to the right of the S.D.) make the host bits all 1's. This gives you the Broadcast IP Address on this subnet. This is the **result** for **"Broadcast Address of This Subnet,"** or in our example **138.101.114.255.**

Step 6 - Determine the maximum number of subnets and usable subnets:

The maximum number of subnets is determined by how many bits are in the subnet counting range (in this example, 10 bits).

Two methods:

Exponents

1. Use the formula 2^n - 2, where n is the number of bits borrowed form the host field.
2. 2^{10} = 1024.
3. Subtract 2 for the number of usable subnets. 1024 - 2 = 1022

Charting

1024	**512**	**256**	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
0	1	1	1	1	1	1	1	1	1	1

1. Make 10 columns for the 10 subnet bits

2. Convert from binary to decimal. This produces the mask address. 1023 in our example.
3. Subtract 2 for the number of usable subnets

Put the **result** in **"Maximum # of Subnets s = sn - 2,"** where n is the total number of subnets and s is the number of usable subnets. In our example **1022 = (1024 - 2)**

Step 7 - Determine the ordinal number of this subnets (i.e. which one of this subnet, out of the maximum number of subnets available:

1. Write down all of the bits in the subnet counting range (i.e. between the G.D. and the S.D).
2. Convert this number to decimal.

0111001011 = 459

Or *use the chart*

1024	512	256	128	64	32	16	8	4	2	1
	0	1	1	1	0	0	1	0	1	1

256 + 128 + 64 + 8 + 2 + 1 = 459

This is the result for the "Number of This Subnet," which is the 459th subnet.

Lab Activity 9.3.1 Basic router configuration

Step 1 - Physical Connections.

Connect all of the interfaces including:

- Console: Connect your PC/terminal to the console port via HyperTerminal (9600-8-N-1-no flow)
- Ethernet: Connect Ethernet ports to a hub or a switch using a straight-through cable. Use a cross-over cable if going directly between Ethernet ports on two routers.
- Serial: If going directly between two routers, don't forget to connect one port via the DTE cable and the other via the DCE cable.

Step 2 - Boot up the router.

You may use the setup mode (setup dialogue) but this is to help you with configuring the router using the Cisco IOS commands. The setup mode will only allow you to configure the router with the basic features and not with any advanced features.

Step 3 - Host Name and Passwords.

It is a good idea to begin your configuration with the hostname and passwords. This will remind you what router you are configuring and it is also a good idea to add the security of passwords right away.

```
Router(config)# hostname LabC

LabC(config)# enable secret class

LabC (config)# line vty 0 4
```

{If you are running EFS (Encrypted File System), you may increase the number of telnet sessions to more than 5.}

```
LabC (config-line)# login
LabC (config-line)# password cisco

LabC (config)# line con 0
LabC (config-line)# login
LabC (config-line)# password cisco
```

Step 4 - Adding IP Addresses.

Next lets add the IP addresses, as this is a basic function of configuring routers. Below is an example of configuring both an Ethernet and Serial interface. Don't forget to use the proper subnet mask! For Serial interface with the DCE cable you will need to also add the clocking with the clockrate command.

```
LabC (config)# interface ethernet 0
LabC (config-if)# ip address 223.8.151.1 255.255.255.0
```



```
LabC (config-if)# description LAN Network
LabC (config-if)# no shutdown

LabC (config)# interface serial 0
LabC (config-if)# ip address 204.204.7.1 255.255.255.0
LabC (config-if)# clock rate 56000 {DCE interface only}
LabC (config-if)# no shutdown
LabC (config-if)# description Network to Lab D

LabC (config)# interface serial 1
LabC (config-if)# ip address 199.6.13.2 255.255.255.0
LabC (config-if)# no shutdown
LabC (config-if)# description Network to Lab B
```

Step 5a - Adding Dynamic Routing: RIP.

If this router will be participating in a dynamic routing protocol like RIP or IGRP, you will need to enable the routing protocol along with those directly connected networks that will be participating. Only use the classful network address, not the subnet address of the network!

```
LabC (config)# router rip
LabC (config-router)# network 199.6.13.0 {NOT Subnet
Address}
LabC (config-router)# network 204.204.7.0 {NOT Subnet
Address}
```

Step 5b - Adding Dynamic Routing: IGRP.

IGRP uses an autonomous system number or process id. This number must be the same on all routers sharing the same IGRP routing updates.

```
LabC (config)# router igrp 10 {10 = autonomous-system
a.k.a. process-id}
LabC (config-router)# network 199.6.13.0 {NOT Subnet
Address}
LabC (config-router)# network 204.204.7.0 {NOT Subnet
Address}
```

Step 6 - Adding Default Routes.

Good candidates for default routes are routers which are known as the boundary router. This is a router which is normally part of a stub network. Inside the stub network, the routers may be participating in a dynamic routing protocol like RIP, but only a static default route is needed to connect the stub network to the Internet. Static routes, including default routes, are propagated with dynamic routing updates. Here are two examples. Either one will work.

```
LabA (config)# ip route 0.0.0.0 0.0.0.0 201.100.11.2
{Adding a default route using a static route.}

LabA (config)# ip default-network 201.100.11.0
{Adding a default route using a the default-network
command..}
```


Step 7 - Adding Static Routes.

A static route can be used for various reasons. One reason may be for a router to connect to a stub network.

LabB (config)# **ip route 205.7.5.0 255.255.255.0 201.100.11.1**
LabB (config)# **ip route 192.5.5.0 255.255.255.0 201.100.11.1**

Step 8 - Testing and Monitoring.

At this point it is a good idea to start testing your network using various commands.

LabC# **show ip route**
LabC # **show ip interface brief**
LabC # **show controller s 0** *{Shows whether or not the serial cable is DCE or DTE.}*
LabC # **ping ip-address**
LabC # **trace ip-address**
LabC # **debug ip rip** *{Remember to turn debug off when done, no debug all}*
LabC # **terminal monitor** *{If using debug from a telnet session, otherwise debug output will go to the console. Caution: This will cause the debug output to go to all telnet sessions on this router.}*
LabC # **terminal no monitor** *{To turn off monitoring during a telnet session.}*
LabC # **show cdp neighbors**
LabC # **show ip protocols**
LabC # **show version**
LabC # **show flash**

Step 9 - Finishing up.

Once everything is working you may wish to add some commands to make your work easier.

LabC (config)# **ip host LabB 199.6.13.1** *{Mapping names and IP addresses.)*
LabC (config)# **ip name-server 223.8.151.10** *{Adding a name server.}*
LabC (config)# **no ip domain-lookup** *{When there is no domain server.}*
LabC (config)# **banner motd # LabC Router, Authorized Access Only! #**
LabC (config-router)# **passive-interface e 0**
{When you do no want to advertise routing tables out of a specific interface.)

And don't forget to...


```
LabC # show running-config
LabC # copy running-config startup-config
```

Miscellaneous

```
LabC # ? {This command can be used by itself or following
at the end of any partial command line.}
LabC > enable
LabC # disable
LabC # configure terminal
LabC (config)# exit
LabC (config-if)# control-z
LabC # clock set 15:10:30 27 May 2000
```

Editing Commands

Control-A: Moves to the beginning of the command line.
Control-E: Moves to the end of the command line.
Esc-B: Moves back one word.
Control F: Moves forward one character.
Control-B: Move back one character.
Esc F: Moves forward one word.

Command History Commands

Control P or **up arrow key**: Recalls last (previous command).
Control N or **down arrow key**: Recalls most recent command
Tab key: completes the entry.

```
LabC # show history
LabC # terminal history
LabC # terminal editing
LabC # no terminal editing
```


Lab Activity 9.3.3 Configuring IPX routing

Sample Network: Using the five router lab diagram, we will give the 210.93.105.0 network the IPX 105 network address, and give the 204.204.7.0 network the IPX 7 network address.

Step 1 - Enabling IPX routing.

`LabD (config)#` **`ipx routing`** {enables IPX routing}
`LabD #` **`show protocols`**

Reflection: What differences do you see in the results from the show protocols commands?

`LabE (config)#` **`ipx routing`** {enables IPX routing}

Step 2 - Enabling IPX on interfaces.

It may be a good idea to first review the information on different Novell IPX frame types at this time.

`RouterD`
`LabD (config)#` **`inter e 0`**
`LabD (config-if)#` **`ipx network 105 encapsulation novell-ether`**

`LabD (config)#` **`inter s 1`**
`LabD (config-if)#` **`ipx network 7`** *{The default encapsulation is HDLC on serial interfaces, and is changed via the* **`encapsulation`** *command for that interface.}*

`RouterE`
`LabE (config)#` **`inter e 0`**
`LabE (config-if)#` **`ipx network 105`**
`LabE (config-if)#` **`encapsulation novell-ether`**

Step 3 - Monitoring IPX routing.

`LabD #` **`show ipx route`** *`{displays the IPX routing table}`*
`LabD #` **`show ipx traffic`** *`{show both IPX and SAP update packets}`*
`LabD #` **`show ipx interface e 0`** *`{shows IPX address of an interface, receiving SAP and RIP information}`*
`LabD #` **`show ipx servers`** *`{shows ipx network servers and the contents of the SAP table}`*

Step 4 - Debugging IPX routing.

`LabD #` **`debug ipx routing activity`** *`{displays IPX routing activity}`*
`LabD #` **`debug ipx routing events`** *`{displays IPX routing events}`*

```
LabD # ping
Protocol [ip]: ipx
Target IPX address: 105.0000.0c8e.eafd {IPX interface of
another device. You can get this information from show ipx
interface command on that device. The IPX interface is a
combination of the IPX network address plus the MAC
address.}
```


Lab Activity 9.3.4 Configuring standard and extended IP access lists

Sample Network: You may wish to configure the network below. You will first need to configure the network for dynamic or static routing. (Notice that the IP addresses may have changed from the previous example.)

Example: Permitting only a specific host from the 205.7.5.0 network onto the 192.5.5.0 network

```
LabA (config)# access-list 10 permit host 205.7.5.11

LabA (config)# inter e 0
LabA (config-if)# ip access-group 10 out
```

Example: Denying a specific host from the 205.7.5.0 network onto the 192.5.5.0 network

```
LabA (config)# access-list 10 deny 205.7.5.11
LabA (config)# access-list 10 permit 0.0.0.0
255.255.255.255

{Or LabA(config)# access-list 10 permit any}

LabA (config)# inter e 0
LabA (config-if)# ip access-group 10 out
```

Example: Permitting only hosts from the 210.93.105.0 network onto the 192.5.5.0 network

```
LabA (config)# access-list 10 permit 210.93.105.0
{Or LabA (config)# access-list 10 permit 210.93.105.0
0.0.0.255}

LabA (config)# inter e 0
LabA (config-if)# ip access-group 10 out
```

Example: An access list that will permit telnets destined for the host 223.8.151.10 from the 195.5.5.0, but will prohibit all other telnets from the 195.5.5.0 network into the 223.8.151.0 network. All other traffic is allowed to enter the 223.8.151.0 network.

```
LabA (config)# access-list 101 permit tcp 192.5.5.0
0.0.0.255 223.8.151.10 0.0.0.0 eq 23

LabA (config)# access-list 101 deny tcp 192.5.5.0 0.0.0.255
223.8.151.0 0.0.0.255 eq 23

LabA (config)# access-list 101 permit ip 0.0.0.0
255.255.255.255 0.0.0.0 255.255.255.255

LabA (config)# interface e 0
```



```
LabA (config-if)# ip access-group 101 in
```

<u>Using the host keyword same as the wildcard mask 0.0.0.0:</u>

```
LabA (config)# access-list 101 permit tcp 192.5.5.0
0.0.0.255 223.8.151.10 0.0.0.0 eq 23
```

replaced by

```
LabA (config)# access-list 101 permit tcp 192.5.5.0
0.0.0.255 host 223.8.151.10 eq 23
```

<u>Using the any keyword is the same as the using 0.0.0.0 255.255.255.255</u>

```
LabA (config)# access-list 101 permit ip 0.0.0.0
255.255.255.255 0.0.0.0 255.255.255.255
```

replaced by

```
LabA (config)# access-list 101 permit ip any any
```

NOTE:

Remember there is an implicit deny any (everything) at the end of an access list.

Lab Activity 9.3.11 Booting up the router

Cisco routers boot Cisco IOS software from:

- Flash
- TFTP server
- ROM (not full Cisco IOS)

Multiple source options provide **flexibility and fallback alternatives**
Locating the Cisco IOS Software
Default source for **Cisco IOS** software

- Flash (sequential)
- TFTP server (netboot)
- ROM (partial IOS)

> **NOTE:**
>
> boot system commands can be used to specify the primary IOS source and fallback sequences.

Booting up the router and locating the Cisco IOS.
ROM

1. POST
2. Bootstrap code executed
3. Check Configuration Register value (NVRAM) which can be modified using the config-register command

   0 = ROM Monitor mode
   1 = ROM IOS
   2 - 15 = startup-config in NVRAM

4. Startup-config file: Check for boot system commands (NVRAM)

   If **`boot system`** commands in **`startup-config`**

   a. Run **`boot system`** commands in order they appear in **`startup-config`** to locate the **IOS**
   b. [If boot system commands fail, use default fallback sequence to locate the **IOS** (Flash, TFTP, ROM)]

   If **`no boot system`** commands in **`startup-config`** use the default fallback sequence in locating the **IOS**:

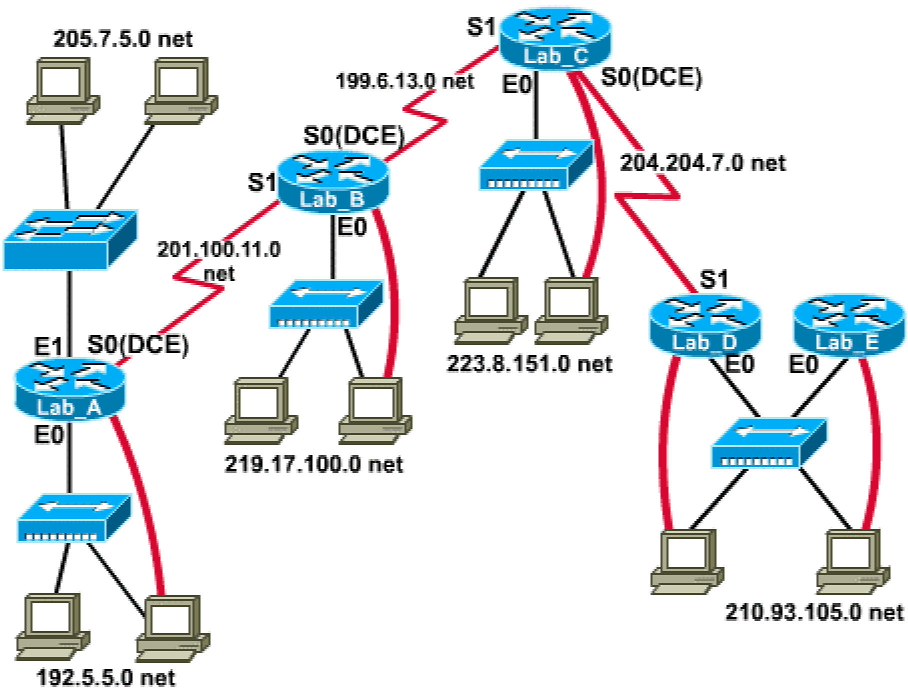
   c. Flash (sequential)
   d. TFTP server (netboot)
   e. ROM (partial IOS) or keep retrying TFTP depending upon router model

5. If IOS is loaded, but there is **no startup-config** file, the router will use the default fallback sequence for locating the IOS and then it will enter **`setup mode`** or the **`setup dialogue`**.
6. If no IOS can be loaded, the router will get the partial IOS version from ROM

Lab Activity 9.10.1.1 Skills-Based Exam #1

1
2

Router Lab Topology



1
2

Router Lab Topology

Router Name	Router Type	E0	E1	S0	S1	SM	Enable Pass-word	Vty Pass-word
Lab_A	2514	192.5.5.1	205.7.5.1	201.100.11.1	--	255.255.255.0	class	cisco
Lab_B	2501	219.17.100.1	--	199.6.13.1	201.100.11.2	255.255.255.0	class	cisco
Lab_C	2501	223.8.151.1	--	204.204.7.1	199.6.13.2	255.255.255.0	class	cisco
Lab_D	2501	210.93.105.1	--	--	204.204.7.2	255.255.255.0	class	cisco
Lab_E	2501	210.93.105.2	--	--	--	255.255.255.0	class	cisco

Objectives

- Analyze the requirements for integrating a router into an existing network
- Practice configuring routers given specific requirements
- Help prepare for the Semester 3 / 4 Skills Based Assessment (SBA) practical final exam

Background:

With this lab you are a network administrator for one of your companies remote sites which is connected to the central corporate offices though a Wide Area Network (WAN) T1 link. Your assignment is to configure your router from scratch based on some specific requirements and corporate guidelines. Your site must connect to the Corporate router which is already configured and must adapt to the IP addressing scheme and protocols being used at the corporate location since you will have no control over the Corporate router. You will also create an Access Control List (ACL) to prevent a certain type of access from your remote site to the corporate location. This lab will help to prepare you for the hands-on Semester 4 Skill Based Assessment final exam. You will work in teams with one team setting up the Corporate router and the other team configuring the Remote router to connect to it.

Tools / Preparation:

Prior to starting the lab, the teacher or lab assistant should have 2 routers available with a WAN link such as routers Lab-A and Lab-B (one for the Remote Site and one for the Corporate Site). Your team should be able to configure your router from scratch using the setup config utility or preferably from the command line. You should try to do this lab without looking at your notes and using only the command line help facility.

Before beginning this lab you should review the Networking Academy Companion Guide chapters on basic router EXEC mode IOS configuration commands, subnet masking, WAN encapsulation and Extended ACLs. You should also review the corresponding on-line chapters. Work in teams of 3 or more. One team is responsible for the configuring the Corporate router and the other team is responsible for configuring the Remote router. The Corporate router team members can look at the answers to ensure that it is configured properly. The Remote router team members can ask questions of the corporate team members but should not see the actual configuration of the Corporate router. They can only use the information given for the Corporate router in the worksheet section of the lab. The following is a list of resources required.

- 2 routers with a IOS 11.2 or later ("Remote" router and "Corporate" router)
- WAN cable link between them with the Corporate router providing the DCE clocking
- Remote router should be connected to an Ethernet LAN
- Workstation connected to the Remote router's console port and the Ethernet LAN
- Corporate router should not be accessible except thru the WAN link

Web Site Resources:

- General information on routers
- 2500 series routers
- 1600 series routers
- Terms and acronyms
- IP routing protocol IOS command summary
- Introduction to WAN technologies

Step 1 - Verify the WAN physical connection between the routers.

Verify that the DCE cable is attached to the **Corporate** router and the DTE cable is attached to **Remote** router. Check the physical cables, each of which should be labeled as either DCE or DTE.

Step 2 - Erase the startup configuration file for the Remote router.

The router startup config file may have already been erased but it is useful to go through the process for practice. If the Remote router configuration file has been erased, you should see a message saying **"Notice: NVRAM invalid, possibly due to write erase."** when the router is powered on. If the router is already on and the prompt is: **Router>** then the startup config file has probably been erased. Verify this by entering privileged EXEC mode with the **enable** command. If the config is blank you will not be prompted for a password. If you issue the **show run** command, none of the interfaces will be configured.

Erase the NVRAM startup configuration file as follows:

Router>enable (since there is no config, you will not be prompted for a password)

Router# erase start
Erasing the nvram filesystem will remove all files! Continue? [confirm]
[OK]
Erase of nvram: complete

Router# reload

Proceed with reload? [confirm]
00:09:30: %SYS-5-RELOAD: Reload requested
System Bootstrap, Version 11.0(10c), SOFTWARE
Copyright (c) 1986-1996 by cisco Systems
2500 processor with 6144 Kbytes of main memory
Notice: NVRAM invalid, possibly due to write erase.

System configuration has been modified. Save? [yes/no]: NO
---- System Configuration Dialog ----
Would you like to enter the initial configuration dialog? [yes/no]: NO

Notes: You may run the config (setup) dialog but you will be prompted for configuration parameters. You should be able to configure the router using only the command line to demonstrate your understanding of router IOS commands and help build your confidence. In practice, you will store the config files on a workstation with a console connection and HyperTerminal or on a TFTP server.

Would you like to terminate autoinstall? [yes]: YES
(Do not allow autoinstall to run and do not enter management configuration mode if prompted)

Step 3 - Verify / Configure the Corporate router.

The Corporate router config team or lab assistant / instructor should use the startup configuration file shown in the answers section to verify that it is configured correctly before the Remote router team tries to configure the Remote router.

> **NOTE:**
>
> The remote team should also review this section carefully since it gives information which will be needed to configure the Remote router later.

The Corporate router should be configured as follows:

1. The router hostname is Corporate
2. Configure the enable secret password to be "class".
3. Configure the password to be "cisco" when someone tries to log in from the console port.
4. Configure the password to be "cisco" when someone tries to telnet into the router.
5. Configure WAN interface S1:
    A. The WAN subnetwork address is one subnet of a class B network address.
    B. The S1 interface address is: 172.16.1.1 (this is already set).
    C. What is the S1 interface subnet mask is? (There are 512 subnets total)

       ____
    D. The S1 interface is providing the DCE clocking at 56000.
    E. Add a description to the S1 interface describing the link:

       ____
6. Configure a static hostname mapping for the Remote router.
7. Add IGRP routing and appropriate network numbers to the router. The AS number is 287.
8. Between the Corporate router and Remote router, use PPP encapsulation.

Step 4 - Configure the Remote router

The **Remote** router config team should configure the **Remote** router as follows:

1. The router hostname is Remote
2. Configure the enable secret password to be "class".
3. Configure the password to be "cisco" when someone tries to log in from the console port.

4. Configure the password to be "cisco" when someone tries to telnet into the router.
5. Configure WAN interface S0:
    a. The WAN subnetwork address is one subnet of a class B network address.
    b. What is the S0 interface address? (must be compatible with Corporate router)

    ____

    c. What is the S0 interface subnet mask? (There are 512 subnets total)

    ____

    d. Add a description to the S0 interface describing the link:

    ____

6. Configure LAN interface E0:
    a. Must be on a valid subnet of the class B corporate network address.
    b. What is the subnet address for the LAN?

    ____

    c. What is the E0 interface address?

    ____

    d. What is the E0 interface subnet mask?

    ____

    e. Add a description to the E0 interface describing the link:

    ____

7. Configure a static hostname mapping for the Corporate router.
8. Add IGRP routing and appropriate network numbers to the router. The AS number is 287
9. Between the Corporate router and Remote router, use PPP encapsulation.
10. Add an Access Control List (ACL) that will prevent telnet from workstations on the LAN attached to the Remote router from getting to the corporate network. All other traffic is permitted.
11. Enter the command here to apply the ACL to the correct interface and in the correct direction:

    ____

Step 5 - Configure the LAN workstation.

The **Remote** config team should configure the workstation that is attached to the LAN as follows:

1. Configure the workstation IP address:

    ____

    (The workstation IP address must be compatible with the E0 interface of the Remote router.)

2. Configure the workstation subnet mask:

___

(Must be compatible with the E0 interface of the Remote router.)Configure the workstation default gateway:

(Reboot the workstation necessary after making TCP/IP configuration changes)

Step 6 - Ping from the Remote router to the Corporate router.

Ping from the Remote router to the S1 interface of the Corporate router.

1. Was the ping successful?

___

2. Why or why not?

___

Step 7 - Ping from the Workstation to the Corporate router.

Ping from the LAN workstation (from the DOS prompt) to the S1 interface of the Corporate router.

1. Was the ping successful?

___

2. Why or why not?

___

Step 8 - Telnet from the Remote router to the Corporate router using IP address.

Telnet from the Remote router to the S1 interface of the Corporate router.

1. Was the telnet successful?

___

2. Why or why not?

___

Step 9 - Telnet from the Remote router to the Corporate router using host name

Telnet from the Remote router to the host name of the Corporate router

1. Was the telnet successful?

___

2. Why or why not?

____

Step 10 - Telnet from the Workstation to the Corporate router.

Telnet from the LAN workstation (from the DOS prompt) to the S1 interface of the Corporate router.

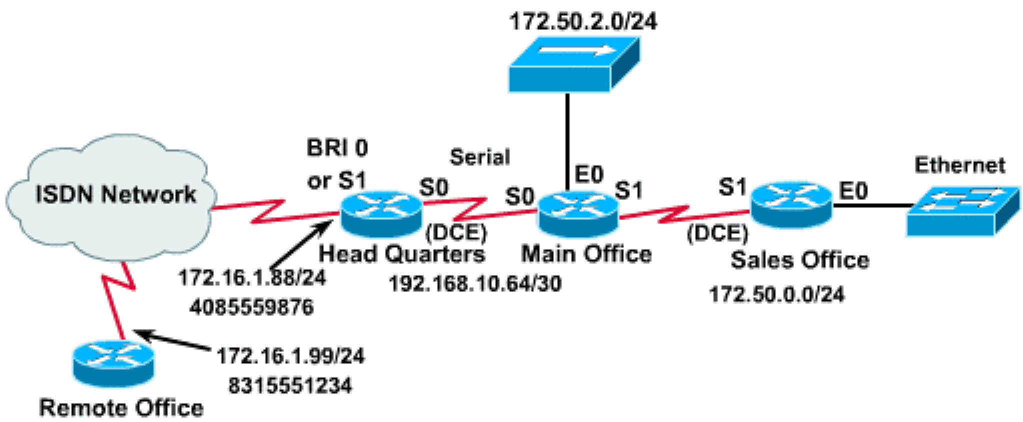
1. Was the telnet successful?

____

2. Why or why not?

____

Lab Activity 9.10.1.2 Skills-Based Exam #2



NOTE: You will only be configuring the Headquarters and MainOffice routers. Assume all other routers have been configured. Because the RemoteOffice and Satellite routers are not physically present, the Headquarters and MainOffice routers will not show any connectivity to these routers and their networks.

The Basics: On both MainOffice and Headquarters Routers

- Configure the hostnames
- Configure proper IP addresses including any other parameters. Configure all interfaces shown in the diagram above for both routers.
- Configure the enable secret password to be "class"

On the MainOffice Router Only

- Add descriptions to the interfaces describing the appropriate links.
- Configure the password to be "cisco" when someone tries to log in from the console port.
- Configure the password to be "cisco" when someone tries to telnet into the router.
- Configure a static hostname mapping for the Satellite router.
- Configure the router to use the domain name server at 172.50.2.10
- Set the clock on the router to show the current date and time
- Add a message of "Authorized access only!" for anyone to see if when they log into the router.

IP Routing and Encapsulation

- Add IGRP routing to all routers in the 172.50.0.0 network.

- Configure a single static route from Headquarters to the 172.50.0.0 network.
- Configure a default route so that all traffic leavi ng the 172.50.0.0 network will travel to the Headquarters router.
- Between Headquarters and MainOffice, use PPP encapsulation with CHAP authentication.

WAN Encapsulation: Headquarters

- Configure the Serial 1 interface with an IP address and for Frame Relay encapsulation
- The remote router has an IP address of 172.16.1.99. Assume Inverse-ARP is disabled and add a statement that will allow Headquarters to be mapped to the remote router's IP address.

Access Lists

- Add an access list to the MainOffice Router that will deny telnets from outside the 172.50.0.0 network, into the 172.50.3.0 subnet. All other traffic is permitted.

Testing

- Headquarters and MainOffice routers should be able to ping each other.

Headquarters Config:

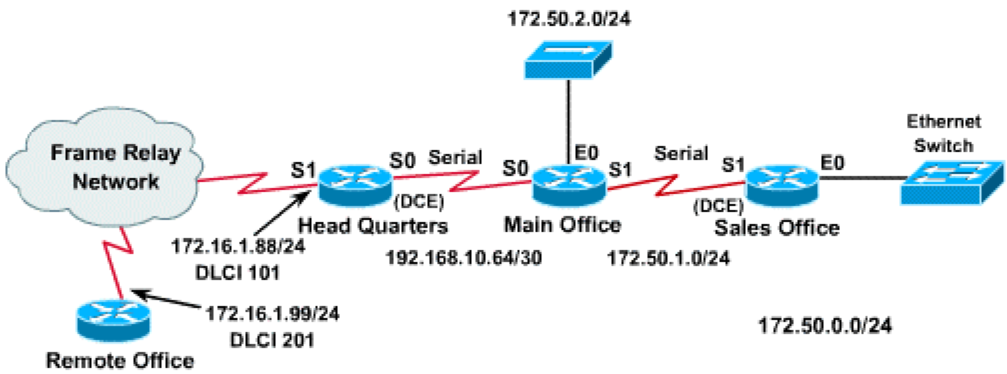
```
hostname Headquarters
!
enable secret 5 $1$AdZW$dgJ0fygeiRZcgkkSrZPyR0
!
username MainOffice password 7 0822404F1A0A
!
interface Ethernet0
no ip address
shutdown
!
interface Serial0
ip address 192.168.10.66 255.255.255.252
encapsulation ppp
no fair-queue
clockrate 56000
ppp authentication chap
!
interface Serial1
ip address 172.16.1.88 255.255.255.0
encapsulation frame-relay
frame-relay map ip 172.16.1.99 101
!
interface BRI0
no ip address
shutdown
!
no ip classless
ip route 172.50.0.0 255.255.0.0 192.168.10.65
!
!
```



```
line con 0
line aux 0
line vty 0 4
login
!
end
```

MainOffice Config

```
hostname MainOffice
!
enable secret 5 $1$6td8$9Ne7T32hEOI9DT4HGm3RJ1
!
username Headquarters password 7 01100A054818
!
interface Ethernet0
description LAN interface
ip address 172.50.2.1 255.255.255.0
!
interface Serial0
description Link to Headquarters
ip address 192.168.10.65 255.255.255.252
ip access-group 101 in
encapsulation ppp
no fair-queue
ppp authentication chap
!
interface Serial1
description Link to Satellite
ip address 172.50.1.1 255.255.255.0
!
interface BRI0
no ip address
shutdown
!
router igrp 10
network 172.50.0.0
!
ip host Satellite 172.50.1.2
ip name-server 172.50.2.10
no ip classless
ip route 0.0.0.0 0.0.0.0 192.168.10.66
access-list 101 deny tcp any 172.50.3.0 0.0.0.255 eq telnet
access-list 101 permit ip any any
!
banner motd ^C Authorized acess only! ^C
!
line con 0
password cisco
login
line aux 0
line vty 0 4
password cisco
login
!
end
```

NOTE: You will only be configuring the Headquarters router. Assume all other routers have been configured. Because the MainOffice, RemoteOffice and SalesOffice routers are not physically present, the Headquarters router will not show any connectivity to these routers and their networks.

The Basics:

- Configure the hostname.
- Configure proper IP addresses including any other parameters. Configure all interfaces shown in the diagram above for the Headquarters router.
- Configure the enable secret password to be "class"
- Add descriptions to the interfaces describing the appropriate links.
- Configure the password to be "cisco" when someone tries to log in from the console port.
- Configure the password to be "cisco" when someone tries to telnet into the router.
- Configure a static hostname mapping for the SalesOffice router.
- Configure the router to use the domain name server at 172.50.1.10
- Set the clock on the router to show the current date and time.
- Add a message of "Authorized access only!" for anyone to see if when they log into the router.

IP Routing and Encapsulation

- Add IGRP routing for the 172.50.0.0 network.
- Configure a single static route from Headquarters to the 172.16.0.0 network.
- Configure a default route so that all traffic leaving the 172.50.0.0 network will travel to the MainOffice router.
- Between Headquarters and MainOffice, use PPP encapsulation with CHAP authentication.

WAN Encapsulation

- Configure the Serial 1 interface with an IP address and for Frame Relay encapsulation
- The remote router has an IP address of 172.16.1.99. Assume Inverse-ARP is disabled and add a statement that will allow Headquarters to be mapped to the remote router's IP address.

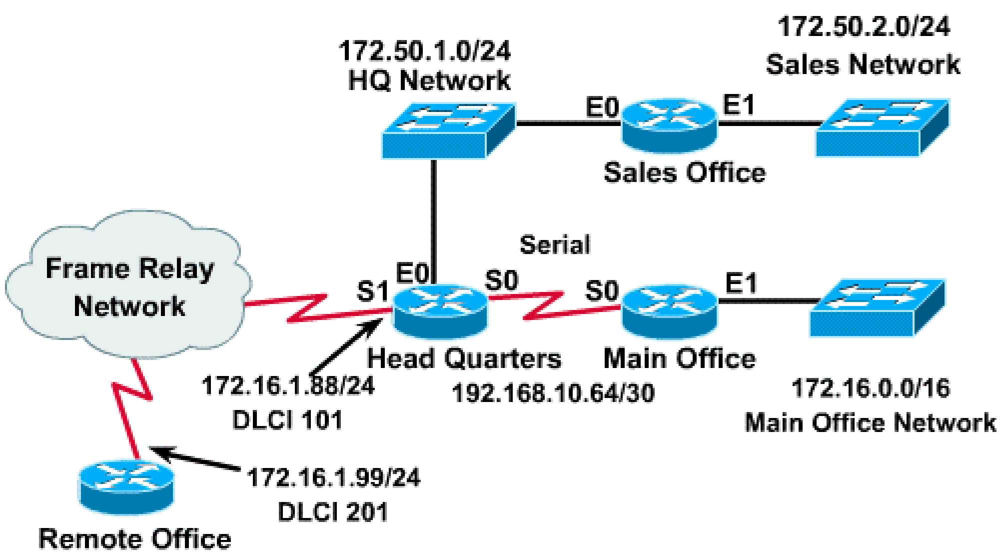
Access Lists

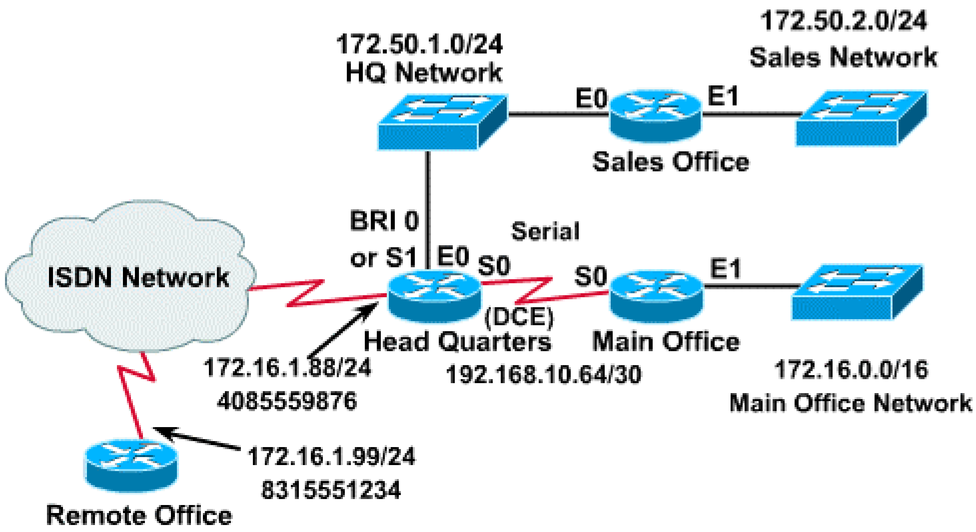
- Add an access list to the Headquarters router that will allow only telnets from the 172.16.0.0 network to enter the 172.50.0.0 network. All other telnets are not permitted, but all other traffic is permitted.

Additional Options and Scenarios

Depending upon the amount of time given to the students, the instructor may wish to include the additional options below or use the options below to replace some of the configurations in the scenario.

ISDN Options





- Configure the Headquarters for ISDN using the BRI 0 port (use Serial 1 if there is no BRI 0 port on your router).
- The type of ISDN switch you are connected to is an NT DMS-100 and your SPID is 0143239999.
- Create a dialer map to access the RemoteOffice router.

Headquarters

```
Headquarters (config)# isdn switch-type basic-dms100
Headquarters (config)# dialer-list 1 protocol ip list 101

Headquarters (config)# interface bri 0
Headquarters (config-if)# ip add 172.16.1.88 255.255.255.0
Headquarters (config-if)# dialer-group 1
Headquarters (config-if)# dialer map ip 172.16.1.99 name
ISP 8315551234
Headquarters (config-if)# isdn spid1 0143239999
```

Routing IPX Options:

- **Scenario 1:** On Ethernet 0, configure the MainOffice router to include IPX routing for the IPX network 4a9. The layer 2 encapsulation used is sap.
- **Scenario 1:** On Ethernet 0, configure the MainOffice router to include IPX routing for the IPX network 4a9 and 3e. The layer 2 encapsulation used is for the 4a9 network is sap, whereas the encapsulation for the 3e network is novell-ether.
- **Scenario 2:** On Ethernet 0, configure the Headquarters router to include IPX routing for the IPX network 4a9. The layer 2 encapsulation used is sap.
- **Scenario 2:** On Ethernet 0, configure the Headquarters router to include IPX routing for the IPX network 4a9 and 3e. The layer 2 encapsulation used is for the 4a9 network is sap, whereas the encapsulation for the 3e network is novell-ether.

Single Encapsulation Options:

```
Router(config)# ipx routing
```



```
Router (config)# inter e 0
Router (config-if)# ipx network 4a9 encapsulation sap
```

Multiple Encapsulation Options:

```
Router(config)# ipx routing

Router (config)# inter e 0.1
Router (config-subif)# ipx network 4a9 encapsulation sap

Router (config)# inter e 0.2
Router (config-subif)# ipx network 3e encapsulation novell-
ether
```

